50X1-HUM

Amplification of Radio-Frequency Currents With Germanium Crystal Triodes (Transistors)

[A Summary]

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I. Introduction

In the introduction, credit for the idea of generating and amplifying radio signals in a device very similar to crystal detectors is given to Soviet physicist O. V. Losev. In the 1920's, Losev supposedly constructed an amplifying circuit (called a "crystadyne") which he used for the generation of rf oscillations. The remainder of this section deals with the advantages (absence of a vacuum and power supply for heating a filament and low weight) and disadvantages (high noise level, low power-handling capacity, and difficulty of matching several elements in a multistage amplifier) of the transistor.

II. Properties of Germanium

This section includes two tables, one comparing some characteristics (crystal structure, melting point, boiling point, density, external appearance, resistivity, and type of conductivity) of carbon, silicon, germanium, and tin, and the other giving the physical properties (atomic weight, number, and radius, compressibility, resistivity, Hall coefficient, coefficient of reflection, electron mobility, magnetic susceptibility, specific heat, and characteristic temperature) of germanium. The accompanying text deals briefly with the method of obtaining germanium, the effect of impurities (aluminum, tin, arsenic, and gallium are mentioned specifically) on resistivity, the "anomalous" reflection coefficient of germanium, and the mechanisms of the "inherent" and "impurity" conductivities of germanium.

III. The Construction and Principle of Operation of the Crystal Triode

The crystal triode discussed in this section is the one originally developed by Bardeen and Brattain. A drawing of the "coaxial" transistor is shown, and it is stated to be in "series" production. In discussing the principle of operation of transistors, Haynes and Shockley's experiments with a long thin plate of germanium in which electrodes of large area were electrolytically deposited on both ends are mentioned. These experiments supposedly demonstrated convincingly that "electron holes" are transferred directly into the germanium layer. Also mentioned are Shockley and Rider's experiments with a plate of germanium in the form of a wedge, with the electrodes deposited at the narrow and broad ends.

IV. Transistor Characteristics

In this section, the static and dynamic characteristics of transistors are obtained from a consideration of four variables, namely, emitter and collector currents and voltages. Emitter and collector currents are chosen as independent variables. Characteristics of transistors studidd by Bardeen and Brattain are used for typical values.

V. Effect of Signal Frequency, Distance Between Point Contacts, and Temperature Upon the Operation of a Germanium Triode. Noise Level

The frequency limit mentioned, taken from Becker and Shive, is 10 Mc. The way in which the distance between point contacts affects transistor operation is discussed. It is claimed that very little data is available on the change of transistor characteristics with temperature. The last papagraph summarizes Beckers studies on the noise factor of transistors.

VI. Connection of Transistors Into Circuits; The Crystal Tetrode

The grounded-base, grounded-emitter, and grounded-collector circuits are discussed. A crystal tetrode, data on which was orginally published by F. Lehan in the August 1949 issue of Electronics, is mentioned in connection with its use as a frequency converter. The following paragraph, which summarizes the author's regard for the present potentialities of transistors, is translated in full:

"The use of crystal triodes for high-quality amplification of audio frequencies has been complicated for the present by the comparatively high noise level, but the transistor because of its obvious advantages has already found use in some special fields. For example, an audio oscillator was used in the radio range finder [Gibson Girl] of a rocket, where the crystal triode was selected over the vacuum tube because of its small size and mechanical stability. It is probable that the transistor will also find be used primarily in computers, [with Thesis] where many hundreds of amplifying units, and in telemechanica switching equipments".

VII. Additional Information on the Principle of Operation of the Crystal Triode

A quantitative evaluation of a number of values connected with transistor operation, namely: 1) the fields produced in the germanium by the collector current; 2) the time required for holes to drift from emitter to colledtor; 3) current amplification in the collector; and 4) feedback resistance.

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